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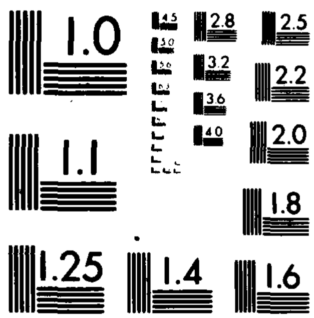

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Planning is a Problem in Synthesis and Not Simply of Analysis

James F. Milne
Undersea Ranges Department

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Preface

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Reviewed and Approved: 15 July 1980

C. S. Seliozy
Head, Undersea Ranges Department

The author of this report is located at the
Newport Laboratory, Naval Underwater Systems Center
Newport, Rhode Island 02840

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This document postulates that any effort to achieve an objective is characterized by heuristic iterations of hypothesis and analysis. An emotion model that provides the motivation for the iterations of hypothesis and analysis is suggested. The emotion model and the experience with heuristic iterations of hypothesis and analysis are used to form a convergence postulate. The convergence postulate describes the general nature of the change that occurs with time in the probability of successful achievement of hypothesized scenarios

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20. Abstract (Cont'd)

The concept of a taxonomy of hypothesized scenarios is briefly outlined and related to the convergence postulate. A planning strategy based on the use of the convergence postulate and a taxonomy of scenarios is outlined.

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Planning is a Problem in Synthesis and Not Simply of Analysis

1.0 Introduction and Assumptions

Existing planning methods, in general, assume that the planners, at some early stage of development, know how an objective is to be achieved. The plan is usually a particular sequence of activities where uncertainty, to some extent, is accommodated by providing optimistic, most probable, and pessimistic cost and schedule estimates. The existing planning methodology is characterized by structuring, processing, and analyzing input data, but little attention is paid to how the input data were identified and generated.

The probability that a postulated plan will be successful is dependent on the relevance and validity of the input data used to form the plan. An apparent dilemma exists if, at the start of a program, there is little relevant information available. If a plan is formed using limited information, then it will have a low probability of success in achieving the objective. On the other hand, new relevant information can be gathered only by having some kind of plan with which to initiate a program.

Resolving this dilemma is not simple. Suggesting that the first action is to gather relevant information only begs the question. How is it known what information should be gathered, and how is it to be gathered?

The dilemma is resolved if we accept the fact that a first plan based on limited information has a low probability of successfully achieving the objective. The planning effort then becomes one of using the new relevant information generated from the initial activity to modify the original plan to improve the probability of success. Planning now becomes a continuing and integral part of a program as opposed to being a reference or guide that is independent of the results of the activity of the program.

In brief, planners must be concerned about how the relevant information input was identified and how it was used. The identification and utilization of relevant information is a synthesis problem.

Synthesis is defined in the Random House dictionary[1] as "the combining of the constituent elements of separate material or abstract entities into a single or unified entity (opposed to analysis)." This common concept is inconsistent with the belief that new concepts or configurations are developed by heuristic iterations of hypothesis and analysis. One implication of the latter belief is that the procedure does not start with separate detail, but with a holistic postulate that can be analyzed. The most difficult problem in planning is not to define how information is to be gathered or generated, but to define the information itself.

Suggesting that the initial phases of a plan should be dedicated to gathering the required detail on which the plan should be based merely begs the question. How is it known a priori which detail is relevant and how it is to be utilized? The belief that this information will be supplied by the technical experts is one of the reasons for the all too frequent dichotomy between the technical expert and resources management. As a program manager, the author has often been in the ludicrous position of asking for more and more planning detail at the start of a program to fulfill a contractual commitment for such detail. Contemplation of speculative detail has value, but proposing a specific sequence of events scenario on the basis of increasingly speculative detail does not increase the probability of success.

The general assumptions about synthesis made in this paper are compatible with the logical concepts established by Karl Popper[2] in debunking the inductive method. The postulate that synthesis and planning are achieved by heuristic iterations of hypothesis and analysis is assumed here to be correct. The scope of this statement may be challenged on the basis that, in many cases, the relevant and quantitative data are available to immediately establish a particular sequence of activities to achieve an objective. Consider the case of building 10 houses exactly the same as 20 that have already been successfully built. If the only objective is to build more houses, the availability of the same materials and labor skills, the same weather conditions, and land with the same characteristics are the considerations. If the objective is to make a profit, the scenario is more complex because possible changes in the cost as well as the availability of the constituent parts must be considered. Options to combat increasing costs may include cutting back on quality and/or size in order to hold the cost of the end product. The problem is even more complex if the increases in costs are not known until after production of the new houses has started. Again, the future is uncertain, and the only option we have is to hypothesize new activities to achieve either a modified objective or the original objective in a different environment.

The postulate concerning heuristic iterations of hypothesis and analysis may also appear to beg the question because it does not explain how the hypotheses are generated. The major advantage of this postulate is that it assumes iterations, and there is no a priori assumption that the initial hypothesis will have a high probability of success in meeting the objective. Success is still the goal, but the approach is to converge on success by a sequence of hypotheses that have an increasingly higher probability of success. Thus the initial hypothesis may be fact or fantasy, and the expectation of success at that time can be no better than our ability to classify the hypothesis and compare it with past scenarios.

Some benefit can be derived by examining, from a different point of view, the postulate that an objective is achieved by iterations of hypothesis and analysis. Logical structuring and quantitative analysis do not intrinsically yield the motivation to achieve an objective. It would appear that we have to seek an emotional source for the motivation. Emotions such as hunger or sex may supply the initial drive, but they do not appear to have any intrinsic tendency to motivate iterations of hypothesis and analysis. However, if we assume the existence of another emotion, for example, a general anxiety about the future and the success of any postulated scenario, then we have an emotion model for hypothesis and analysis. Consider a person in a primitive environment who is very thirsty. Some

initial scenarios might consist of emotionally satisfying daydreams about drinking water to satisfy the thirst, but these scenarios would also be influenced by the emotional desire for success, which would draw on past knowledge of where water existed. This desire for success may in turn lead to scenarios of getting to the water. These scenarios in turn would be analyzed to determine the time required to reach the water and the possible dangers en route. It is not the purpose here to investigate the nature of creativity and the human thought process, although it has been observed by A. S. Rothenberg[3] that anxiety appears to exist when highly creative people are in action. Interesting correlations can be made between the iterations of hypothesis and analysis postulate and some studies on the evolution of intelligence.[4]

What is of interest here is that the postulated emotion model that motivates iterations of hypothesis and analysis also provides an explanation for some of the conflicts between the demands for success through planning and the reality of what can be achieved based on relevant past experience. Planning can be used as a security blanket to create the illusion of being in control; anxiety about the successful outcome sometimes becomes so dominant that we lose sight of the original purpose. This anxiety may take the form of bounding the problem to make it analytically solvable, particularly if a mathematical model is involved with bounds that are so restricting that the solution makes little contribution to the original problem. Another form that anxiety may take is the generation and use of "efficient management procedures" that become an end unto themselves and cause those involved to lose sight of the real end product. This is the type of scenario in which the operation was a success, but the patient died.

The problem was succulently put by the player king in Shakespeare's Hamlet:

> "Our wills and fates do so contrary run
> That our devices still are overthrown;
> Our thoughts are ours, their ends none of our own."

2.0 Convergence on an Objective Postulate

The discussions in section 1.0 suggested that any planning process must accommodate the general procedure of heuristic iterations of hypothesis and analysis. Although a detailed examination of how hypotheses are formed is beyond the scope of this paper, we can make some general observations on how the nature of the hypotheses changes from the identification of a need to the achievement of an objective. Initially the hypotheses are emotionally satisfying scenarios and have a low information content. As we improve the probability of successful achievement of an objective, the scenarios are principally motivated by a desire for success and have a higher information content. The initial scenarios are emotionally satisfying in that they meet the original emotional need. The final scenarios are shaped by the desire for success and are based on past experience that may include data specifically generated to meet the identified objective.

Successful achievement of an objective is the general goal of planning, and we now pursue the changing nature of the hypotheses that occur with time in terms of the change in the Probability of Successful Achievement (POSA) of the objective.

The change in the probability that the hypothesized sequence of events will, with time, achieve an objective is postulated to be as shown in figure 1. The start of the curve is based on the assumption that at time zero no relevant information has been drawn from memory or any external source. This implies that we have no quantitative definition of an objective because that would require a relevant information content with greater than zero probability of achievement. The initial motivation to act is emotional, and the scenarios, if any, are in symbolic form. A discussion of the postulate that human emotions are still compatible with survival in the present environment and, even in their symbolic form, have a better than zero probability of success is beyond the scope of this paper.

The initial shape of the curve with the high rate of change is based on the postulate that initially the little to no relevant information places little to no restrictions on the hypothesized scenarios. The initial scenarios are highly emotional and satisfaction-oriented with few, if any, real constraints and may be more fantasy than fact. A relatively small amount of relevant data can be used to eliminate the fantasies and rapidly increase the probability of realistic attainment. The more we increase the probability of success of the hypothesized scenario, the greater the requirement for relevant data--to the point that all possible contingencies must be covered to guarantee success. Part of the effort to cover all contingencies is to control the environment so that certain things will or will not occur. However, there is always some uncertainty about the future, and the best that can be done is to tend toward certainty.

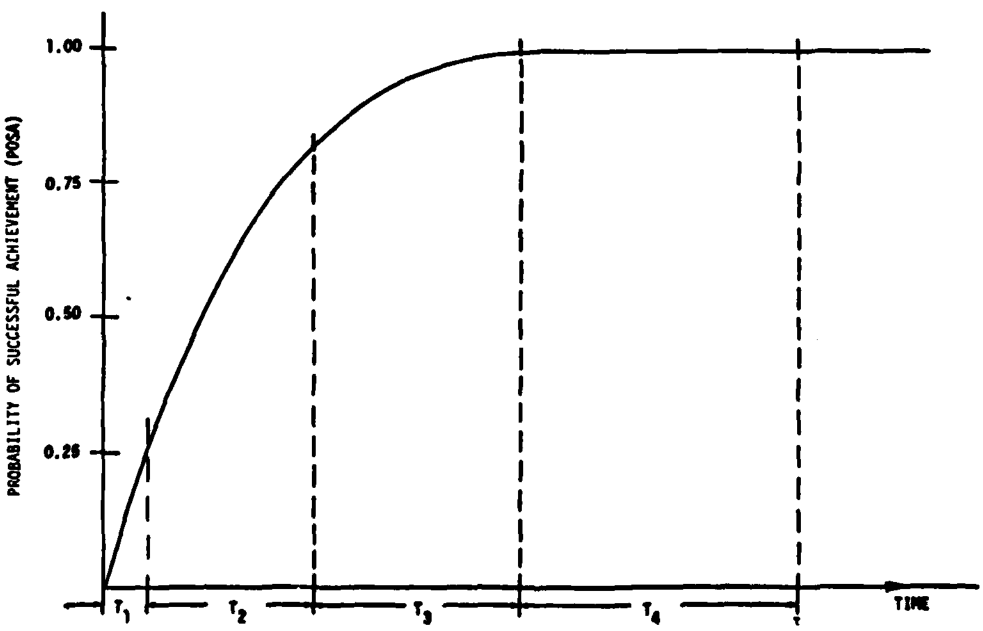

Figure 1. General POSA Curve

Activities are limited by time and available resources. If we are to achieve objectives, we must pursue a sequence of activities without ever having a certainty of success. The question from a planning point of view is "Are we converging on the successful achievement of an objective and how fast is the convergence?" Figure 1 suggests the general shape for the rate of convergence that will ensure success. Using this as a reference, we now examine the time dependent nature of the hypothesized scenarios from time zero to time τ. An implication is that a plan is not merely something formed at the start of the effort to achieve an objective, but is an integral part of the total effort. A plan should not be a road map that is formed with little information at the start of an effort and is then pursued without deviation regardless of the information generated during the effort. This concept is compatible with management by objectives,[5] which has detailed the changing nature of the definition of an objective.

Assume that at time τ, some objective has been successfully achieved. Based on the heuristic iterations of hypothesis and analysis assumption, we can arbitrarily suggest four phases of development with time as shown by T_1, T_2, T_3, and T_4 in figure 1.

The first phase, T_1, consists of scenarios that are emotionally satisfying but that have been classified only as fact or fantasy. This is probably the most significant and least understood phase of any endeavor. Because the satisfying scenarios in this phase are initially uninhibited by the success or failure of past experience, there is an infinite number of possible scenarios. By the same token, innovations are made in this phase by postulating scenarios that have never been conceived before. The elimination of fantasies is based on past experience, but in order to progress, some new scenarios must be pursued. Most of the relevant data used in this phase are from individual memory. Neither systematic data gathering nor quantitative analysis is conducted.

Phase T_2 consists of scenarios believed to be achievable, and the overall characteristics are compared with similar scenarios enacted in the past. A large number of scenarios is possible and analysis consists, in general, of pattern recognition and/or classification. Data on similar past scenarios are gathered, but comparing the overall characteristics of past scenarios with the hypothesized scenario is the primary interest. Any existing management techniques such as work breakdown structures, task statements, PERT charts, finite mathematics, etc., may be introduced in phase T_2. The critical control factor is the detail that is available, not the detail that is required by the management system. The above management techniques should be used in the classification and comparison effort and/or the development of new scenarios, instead of imposing a particular sequence of events scenario complete with time schedules and cost estimates.

The scenarios of phase T_3 are described in detail and may be subjected to quantitative analyses and comparisons. Detail that is unique to the identified objective will be generated.

The final phase, T_4, is a particular sequence of activities scenario in which, for the first time, a specific and well defined objective exists, and a particular sequence of activities has been defined to achieve the objective.

A convergence postulate that suggests the general nature of the change in the POSA that occurs with time has been described along with the general characteristics of the scenarios in four successive phases. The curve shown in figure 1 is for an effort that does converge on achievement of an objective at time τ. Unfortunately, all efforts do not converge on achievement of an objective at a rate compatible with the available time and resources. It is assumed that with infinite time and resources any objective can be achieved.

3.0 Interpretation of Planning Based on Convergence Postulate

The purpose of planning is to improve the probability of success, and the convergence postulate does not provide any specific procedure for achieving this. Indeed, because there is an inadequate understanding of how hypotheses are generated, there seems little chance of estimating the number of iterations of hypothesis and analysis required to achieve an objective. However, if we can identify and classify the characteristics of hypothesized scenarios, we may be able, after a scenario has been formed, to state where we are on the curve of figure 1. The four-phase sequence T_1, T_2, T_3, and T_4 introduced a primitive reference for the changing nature of scenario development.

A numerical framework is now introduced to facilitate the discussion of the relationship between the convergence postulate and a taxonomy of scenarios. The hyperbolic function TANH Kt is used to generate the four curves of figure 2, where

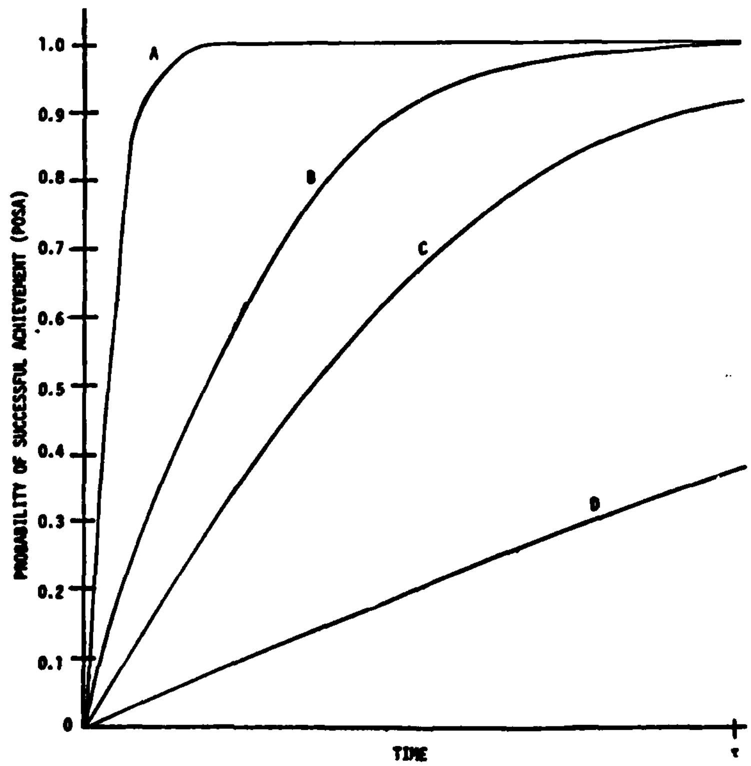

Figure 2. Different Rates of Change of POSA

K was set at 8, 1.5, 0.8, and 0.4 for A, B, C, and D, respectively. This numerical framework is introduced as a reference for communication and no particular merit is claimed for the hyperbolic function TANH Kt over any other function giving a similarly shaped curve. The selection of four time phases and four different rates of change, A, B, C, and D, is arbitrary.

The curve of figure 1 indicates that the rate of change of the POSA in phase T_1 is decreasing and that as we progress beyond phase T_1 towards success, it will continue to decrease. A primitive classification of the scenarios in terms of four time phases, T_1, T_2, T_3, and T_4, was described, and it was suggested that identification of the scenario class would indicate the position of the plan on the convergence curve. The concept of using a suitable taxonomy of scenarios with the convergence postulate to indicate the future trend of a program is now explored.

The scenarios in phases T_1 and T_2 are based on pattern recognition comparisons with past experience. During phase T_3 this gives way to scenarios that are based on information gathered or generated for the specific activities of the postulated scenario. Scenarios in phase T_4 are dominated by information that is particular to the activities of the postulated scenario.

The following are typical of the dimensions from a suitable taxonomy of scenarios that can be used during phase T_2 to identify the rates of convergence A, B, C, or D of the postulated scenario.

Rate of Change A: Scenarios that follow this rate of change are very similar to scenarios done in the past, and/or they include a wealth of existing applicable empirical data and/or established theory. There are no significant restrictions on the available resources. The environment is, to a large extent, controllable or predictable. Because the majority of the data in phase T_2 is from individual memory, the implication is that the people engaged have significant relevant information and capability. The end objective is thought to be achievable.

Rate of Change B: Scenarios that follow this rate of change are similar to scenarios done in the past, and/or they include existing applicable empirical data and/or established theory. Sufficient resources are thought to be available, and the environment is, to some extent, controllable or predictable. Again it is implied that the people engaged have relevant information and capability. The end objective is thought to be achievable.

Rate of Change C: Scenarios of a similar kind have been done in the past, but the existing empirical data are not directly applicable, and established theory has not previously been applied to all aspects of the scenario. Sufficient resources are thought to be available, and the environment may be controlled or predicted to a limited extent. The people engaged have relevant information and capability. The objective is not known to be achievable in light of the past history of scenarios of the same class. Pursuit in phase T_2 of this class of scenario is common and always undertaken with the hope that the current effort will improve the rate of change of the POSA.

Rate of Change D: Comparison with past scenarios is based on a lack of relevant information. Existing empirical data, if any, are not directly applicable, and established theory has not previously been applied to achieve a similar objective. Available resources are inadequate, and control or prediction of the environment is uncertain. The people engaged are assumed to have relevant capability. Pursuit of scenarios with these characteristics is justified by the fact that innovation cannot be achieved any other way. It cannot be argued that time τ and the resources should be increased to an amount necessary to achieve the objective because meaningful information to do this does not exist. The resources and time τ are more likely to be based on what the participants have to gamble on the effort. Assessment of the gamble during phase T_2 would appear to be limited to classifying the proposed scenario and comparing it with the past history of scenarios of the same class.

It may be difficult or impossible to determine the rate of convergence of scenarios that are not based on existing theory or similar scenarios. For example, humans had the desire to fly at a time when the only relevant data was the fact that heavier-than-air bodies such as birds could fly, whereas humans had only a long history of failure trying to fly.

Scenarios with rate of change D characteristics and no relevant capability on the part of the participants may converge only under the pathological condition of infinite time and resources.

A suitable taxonomy might, with greater difficulty, be developed to relate postulated scenarios to convergence rates A, B, C, and D during phase T_1. This is the time of creative thinking, and the convergence may depend on such things as the established creative/intellectual capability of the participants. Breakthroughs in human thinking are often made by running a course outside of the established understanding of the nature of the problem.

During phase T_3, prediction of the convergence rate is based on two inputs: (1) the continued use of a taxonomy of scenarios to relate the hypothesized scenarios to convergence rates and (2) the emerging estimate of the time τ and the required resources based on the summation of the detailed requirements of the activities of the postulated scenario. Usually estimates based on summation of detail will be more optimistic than those based on past scenarios. During phase T_4, the convergence rate estimate will be based principally on summation of detail of the activities in the postulated scenarios. However, even during this phase, comparing the postulated scenario with similar past scenarios can prove valuable in estimating the convergence rate.

4.0 Planning Procedure

Implementation of the planning strategy requires developing and documenting (1) the information on the convergence postulate, (2) a taxonomy of scenarios, and (3) the relationship between the convergence postulate and a taxonomy of scenarios. Specifically, the following is required:

•Define a numerical reference framework, such as TANH Kt, for the POSA convergence.

•Develop a suitable taxonomy of scenarios.

•Select a convenient number of time phases, and define the characteristics of the scenarios in each of the time phases, using the convergence postulate and the taxonomy of scenarios.

•Select a convenient number of different rates of change of the POSA and define the characteristics of the scenarios for each of the different rates of change for each time phase.

The implementation of the planning strategy is in itself a heuristic and iterative procedure, consisting essentially of the following steps:

1. Classify the initially postulated scenarios in phase T_2, using the taxonomy of scenarios.

2. Identify known past scenarios in the same class.

3. Use the information from the past scenarios of the same class to estimate a time τ and the required resources for the postulated scenario.

4. Select a rate of change for the POSA by comparing the classification of the postulated scenario with the defined characteristics of the scenarios for each of the different rates of change.

5. Continue to classify the evolving scenarios, using the taxonomy of scenarios.

6. Continually identify the time phase by comparing the classification of the postulated scenario with the defined characteristics of the scenarios for each of the time phases. (There may be progress or regression.)

7. Continually identify the rate of change of the POSA by comparing the classification of the postulated scenario with the defined characteristics of the scenarios for each of the different rates of change. The rate of change classification may increase or decrease, resulting in a change in the position on the convergence curve.

8. Use the estimates of the time phase and the rate of change of the POSA to maintain or modify the objective, the estimated value of τ, and the estimate of the required resources. The estimates of the time phase, the rate of change of the POSA, or the required resources may also be used to justify canceling the program.

9. Use the estimates from step 8 above, to modify the emerging estimate for time τ and the required resources obtained from the summation of the details of the activities composing the postulated scenario.

Regardless of the amount of available relevant information, it is assumed that a plan always starts at arbitrary time zero and follows the general shape of the convergence curve in figure 1 to end at time τ unless the effort to satisfy the need is abandoned before time τ. Assume that a higher authority presents a team with a set of data and a scenario that has completed phase T_3 and is a type A convergence. It is required that the history of the T_1, T_2, and T_3 phases be made available. Structured documentation of the decisions associated with the advance or regression through time phases is an essential communication. A communication system for decisions in a hierarchy of authority has been described by the author.[6] If the data presented at the start of a proposed phase T_4 effort are highly speculative and there is no history of iterations of hypothesis and analysis, then there is no real support for the POSA.

5.0 Application

A number of problems appear when the convergence postulate and a suitable taxonomy of scenarios are used in a planning strategy. The first is that a suitable taxonomy has to be developed. The second is that relevant data on past scenarios are often not documented or are proprietary information. There is a tendency to document only successful scenarios and to replace the iterations of hypothesis and analysis by a description of a single sequence of events because a logically structured sequence of events is easier to understand. There is also a tendency to forget failure statistics because, in retrospect, errors become embarassingly obvious; this tendency, of course, provides an unrealistic basis for planning and prediction. Empirical data on the actual costs and time in a past scenario for a competitive product have obvious value to designers and manufacturers.

A third possible problem is that if the best information available indicates that the objective cannot be achieved with a high level of probability within a given time and defined resourses, motivation may suffer.

Despite these limitations, the need to accommodate the heuristic iterations of hypothesis and analysis in thinking fully justifies the exploration of new techniques in planning.

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